

Deepwater Canyons 2013 - Pathways to the Abyss

What Landed on the Lander?

(Supplemental Lesson to *Design a Benthic Lander* from the Deepwater Canyons 2012 Expedition)

Focus

Biological and physical data collected by benthic landers

Grade Level

7-8 (Life Science)

Focus Question

What kinds of information about deepwater ecosystems can be obtained from biological and physical data collected by benthic landers?

Learning Objectives

- Students will construct and defend inferences about types of organisms that may colonize settlement plates attached to benthic landers deployed in mid-Atlantic deepwater canyons.
- Students will interpret data from benthic lander sensors to identify patterns and variability of selected physical conditions in a deepwater marine ecosystem.

Materials

- Copies of Mission Logs, Background Essay, and Fact Sheet listed in Learning Procedure, Step 1, one for each student group; or Internet access to these materials
- Copies of *Guidance for Mission Log Review*; one copy for each student
- (Optional) Materials to demonstrate fluorescence (see Learning Procedure, Step 6)
- (Optional) Copies of Figure 1, one copy for each student group (see Learning Procedure, Step 1d)

Audio-Visual Materials

- (Optional) Interactive white board

Teaching Time

Two 45-minute class periods, plus time for student research

Seating Arrangement

Groups of two or three students

Maximum Number of Students

30

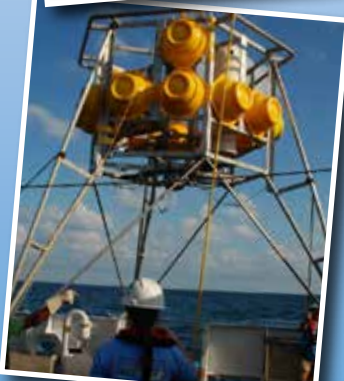
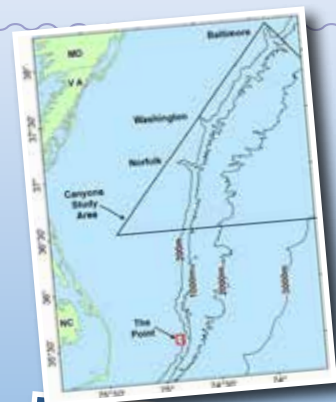
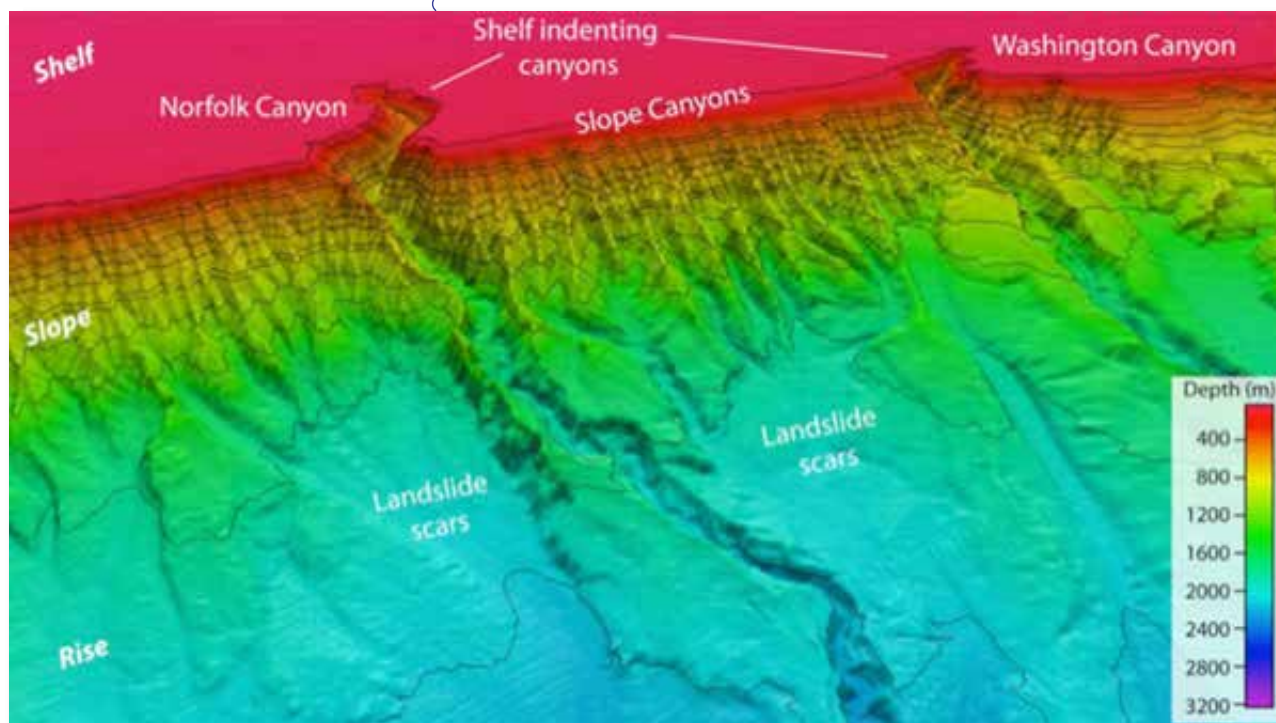


Image captions/credits on Page 2.

lesson plan



Deep submarine canyons are perhaps the most striking feature of the continental margin of the eastern United States. Most of these canyons are relatively minor features, but several are incredibly extensive and cut quite deeply into the seafloor. This image shows the Norfolk and Washington Canyons along the continental margin offshore of Virginia. Image courtesy of USGS.
http://oceanexplorer.noaa.gov/explorations/11midatlantic/background/seafloormapping/media/seafloormapping_fig3.html

Key Words

Atlantic canyon
Benthic community
Benthic lander

Background Information

NOTE: Explanations and procedures in this lesson are written at a level appropriate to professional educators. In presenting and discussing this material with students, educators may need to adapt the language and instructional approach to styles that are best suited to specific student groups.

Background information about deepwater canyons off the east coast of the United States is provided in the Expedition Education Module for the Deepwater Canyons 2012 – Pathways to the Abyss Expedition [<http://oceanexplorer.noaa.gov/explorations/12midatlantic/background/edu/edu.html>], and the *Feeding in the Flow* lesson plan [http://oceanexplorer.noaa.gov/explorations/12midatlantic/background/edu/media/dwc12_feeding912.pdf].

The purpose of the Deepwater Canyons 2013 - Pathways to the Abyss Expedition is to extend work begun in 2012 to explore and investigate deepwater coral and hard bottom communities and shipwreck sites

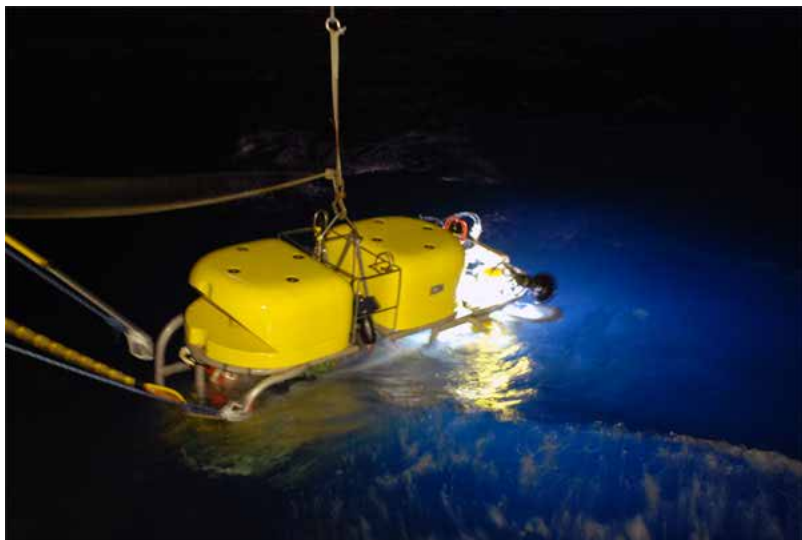
Images from Page 1 top to bottom:

Submarine canyons are dominant features of the outer continental shelf and slope of the U.S. East coast from Cape Hatteras to the Gulf of Maine. Image courtesy of Steve W. Ross, UNC-W.
<http://oceanexplorer.noaa.gov/explorations/12midatlantic/background/canyons/media/studyarea.html>

Netherlands Inst. of Sea Research BOBO benthic lander that will be used in the Middle Atlantic deepwater canyons. Image courtesy of Steve Ross, UNC-W.
<http://oceanexplorer.noaa.gov/explorations/12midatlantic/background/benthiclanders/media/bobo.html>

A goosefish is well camouflaged in any habitat. Image courtesy of Deepwater Canyons 2012 Expedition, NOAA-OER/BOEM.
<http://oceanexplorer.noaa.gov/explorations/12midatlantic/logs/aug27/media/goosefish.html>

A *Lophelia* coral colony seen in Baltimore Canyon. Image courtesy of Deepwater Canyons 2012 Expedition, NOAA-OER/BOEM.
<http://oceanexplorer.noaa.gov/explorations/12midatlantic/logs/sept13/media/lophelia1-hires.jpg>



Lights, camera, action! The *Kraken II* remotely operated vehicle used for the 2012 expedition was built for science and was equipped with all the tools needed for collecting deepwater specimens. Image courtesy of the Deepwater Canyons 2012 Expedition, NOAA-OER/BOEM.

<http://oceanexplorer.noaa.gov/explorations/12midatlantic/logs/sept30/media/kraken.html>

on the continental slope off Virginia, Maryland, and Delaware. This work includes bathymetric mapping, collection of photographic imagery and samples using a remotely operated vehicle, and deploying long-term monitoring instruments to measure physical and chemical conditions including temperature, salinity, turbidity, dissolved oxygen, and bottom currents. In 2012, most of this effort was concentrated on Baltimore Canyon. In 2013, the focus will shift to Norfolk Canyon.

Benthic landers are instrument-carrying platforms that are placed on the seafloor

to record data, often over an extended period of time. Typically, these platforms consist of a metal frame, floatation, and a ballast weight to keep the platform oriented in the desired position. The weight is attached to the platform with an acoustic release device that will release the weight and allow the platform to surface when an appropriate acoustic signal is received from scientists aboard a surface ship. If an acoustic release system is installed, the platform will also carry signaling devices such as a radio beacon, strobe light, or large flag to help scientists locate the benthic lander after it reaches the ocean surface.

Benthic landers for the Deepwater Canyons - Pathways to the Abyss expeditions carry instruments to measure currents, temperature, salinity, turbidity, dissolved oxygen, fluorescence, and suspended sediment, as well as data loggers to record measurements made by these instruments. In addition, landers will carry biological experiments, such as plates of various materials to investigate larval settlement. Some landers also may have video and/or digital still cameras and acoustic Doppler current profilers to measure currents in the water column. Moorings will carry sediment traps, current meters, and temperature data loggers. For more information about benthic landers, see <http://www.lophelia.org/the-deep/science/scientific-techniques/landers>.

The fact that the Pathways to the Abyss expeditions take place over several subsequent years gives students (as well as expedition scientists) the opportunity to compare conditions in several deepwater canyons, and to see how observations in one area can be used to guide explorations in other locations. In the 2012 *Design a Benthic Lander!* lesson, students planned an investigation to identify appropriate materials for a model that demonstrates the operating principles of a benthic lander. In this lesson, students will use observations from the

Deepwater Canyons 2012 - Pathways to the Abyss Expedition to make inferences about types of organisms that may colonize settlement plates attached to benthic landers deployed in mid-Atlantic deepwater canyons. Optionally, students can interpret data from benthic lander sensors to identify patterns and variability of selected physical conditions in a deepwater marine ecosystem. Mission logs from the 2013 expedition will allow students to compare their inferences with actual discoveries as the 2013 expedition unfolds.

Learning Procedure

1. To prepare for this lesson:

- a. Review the background essays for the Deepwater Canyons 2013 - Pathways to the Abyss Expedition [<http://oceanexplorer.noaa.gov/explorations/13midatlantic/welcome.html>]. If students have not completed the *Design a Benthic Lander!* lesson, you may also want to review background information for this lesson as well [http://oceanexplorer.noaa.gov/explorations/12midatlantic/background/edu/media/dwc12_lander56.pdf]

- b. Ensure that students will have access to the following Mission Logs from the 2012 expedition:

"Microbial Architects" (August 16, 2012) by Christina Kellogg [<http://oceanexplorer.noaa.gov/explorations/12midatlantic/logs/aug16/aug16.html>]

"Energy Flow through Submarine Canyons" (August 20, 2012) by Dr. Gerard Duineveld [<http://oceanexplorer.noaa.gov/explorations/12midatlantic/logs/aug20/aug20.html>]

"Benthic Landers: Critical Tools For Use in Deep-sea Research" by Steve W. Ross [<http://oceanexplorer.noaa.gov/explorations/12midatlantic/background/benthiclanders/benthiclanders.html>]

"Microbial Ecology of Deepwater Canyons" (U.S. Geological Survey Fact Sheet 2011-3102, August 2011)[<http://pubs.usgs.gov/fs/2011/3102/pdf/2011-3102.pdf>]

- c. If you want to demonstrate fluorescence (Step 6), review materials and procedures described in the "Deep Lights" lesson from the Bioluminescence 2009: Living Light on the Deep Sea Floor Expedition [http://oceanexplorer.noaa.gov/explorations/09bioluminescence/background/edu/media/ds_09_deeplights.pdf]
- d. Review Step 6, and decide whether you wish to include this in your lesson. This activity uses actual data from a benthic lander

and provides opportunities to reinforce important concepts about how physical conditions vary in the marine environment, as well as graph interpretation skills; but may be omitted if available time does not permit its inclusion.

2. Briefly describe deepwater canyon habitats. Mention some of the reasons for exploring these habitats, which include the facts that similar sites in other areas are known to support important fisheries and other biological resources, and that cold-seep communities may exist in some locations. If students are not familiar with cold-seep habitats, briefly describe these (see the Expedition Education Module for the *Lophelia* II 2012: Deepwater Platform Corals Expedition, <http://oceanexplorer.noaa.gov/explorations/12lophelia/background/edu/edu.html>, for more details). Point out the significance of potential methane hydrate deposits, including their potential as a new energy source as well as their potential for triggering underwater landslides that can result in tsunamis.

Introduce the Deepwater Canyons 2013 - Pathways to the Abyss Expedition and tell students that this is a continuation of an expedition that began exploring this area in 2012. If students have not completed the *Design a Benthic Lander* lesson, show an image of a benthic lander (<http://oceanexplorer.noaa.gov/explorations/12midatlantic/background/objectives/media/benthiclander.html>), and briefly describe the overall concept.

One of the Benthic Landers deployed during the first leg of the 2012 cruise. This is a platform that can be deployed from the ship and recovered by remotely releasing the weight that secures it to the seafloor. The Landers were equipped with instruments to measure environmental variables and rate of sediment deposition. Image courtesy of Steve Ross, UNC-W.

<http://oceanexplorer.noaa.gov/explorations/12midatlantic/background/objectives/media/benthiclander.html>



3. Provide each student group with copies of the resources referenced in Step 1b or Internet access to these materials. Tell students that their assignment is to review these materials, and prepare a short summary that addresses questions on the *Guidance for Mission Log Review* document. These summaries should be collaborative efforts developed through discussions within each student group after each student has read the assigned material individually. This approach encourages students to discuss various interpretations of the information presented, and to help each other with unfamiliar terms or concepts. Depending upon the time available, you may want to assign each resource to a different student group.
4. When students have completed their reviews, lead a discussion of their results. The key concepts of this lesson are that conditions in submarine canyon ecosystems vary over time; and that extreme events can determine which species inhabit a specific area, even though such events may not last for very long. This variability means that conditions need to be measured frequently and over a long period of time to detect extreme events that are important to understanding the distribution of species in these ecosystems. In addition, the following points also should be included:
 - 1) Dr. Kellogg probably chose "Microbial Architects" as the title for this Mission Log because microbes are often the first organisms to inhabit a surface in the marine environment, and the presence of microorganism can help or interfere with other plants and animals that may try to settle on the same surface.
 - 2) Different kinds of materials are used for settlement plates attached to benthic landers to imitate different kinds of hard surfaces that are found in the marine environment.
 - 3) If you wanted to find out which microbes are the first ones to appear on the settling plates, you would have to look at the plates soon after they were placed in the marine environment and at frequent intervals after that. In the investigation described by Dr. Kellogg, settlement plates are left for a year before they are inspected, and many changes might take place in the organisms that attach to these plates during that long time.
 - 4) Ways that microorganisms may help corals include nutrient cycling and producing substances that prevent harmful microbes from infecting corals.
 - 5) Microorganisms may benefit animals that live in soft sediments by serving as food for these animals, as well as the ways described for corals.

6) "Physical variability" means how conditions such as temperature, water currents, and dissolved oxygen may change during a day, month, or year. Detailed, longer-term data are important because extreme changes in physical conditions may only last for a short period of time, but these temporary events may be enough to prevent some organisms from inhabiting certain habitats.

7) "Temporally" means something that involves time. "Spatially" means something that involves space or physical location.

8) Benthic landers measure temperature once every fifteen minutes, which means four measurements each hour, and 96 measurements in one 24-hour day.

9) Dr. Duineveld says we need continuous observations over a long time period to understand how particles flow in submarine canyons, because flows of particles through canyons are not constant over time but occur in events triggered by hydrodynamics (such as storm waves) and weather conditions.

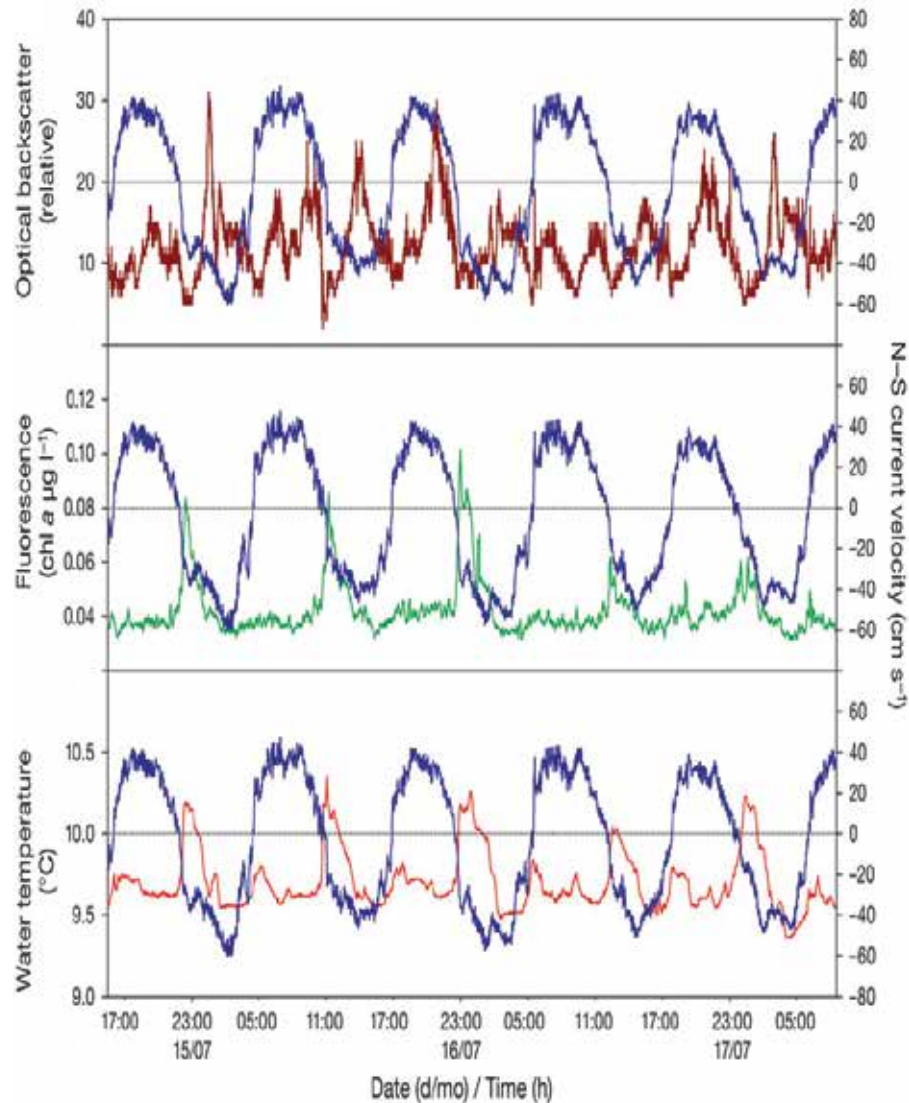
10) The presence or absence of fresh algal particles might help explain where animal communities live in submarine canyons because these particles might be an important source of food for some animals that live in these communities.

5. Have student groups take turns reviewing Mission Logs from the Deepwater Canyons 2013 - Pathways to the Abyss Expedition, and make brief (5 – 10 minute) oral reports about new discoveries, and how observations and events reported in these Logs compare to the inferences discussed in Step 4.

6. (Optional) Provide each student group with a copy of Figure 1 (see page 8). These graphs show data that were collected with sensors attached to a benthic lander that was deployed in the Sea of the Hebrides west of Scotland (Roberts *et al.*, 2009). These sensors measured water currents, optical backscatter, fluorescence, and temperature. Optical backscatter provides a measure of turbidity or particulate material. Fluorescence provides a measure of chlorophyll, which increases when large numbers of phytoplankton (algae) are present. (Note in addition to chlorophyll, many other substances also fluoresce; if you want to demonstrate some of these, see the lesson referenced in Step 1c.) Each graph shows the velocity of water currents (blue line) and one of the other parameters.

Ask students what they can infer from these graphs. Depending upon their graph interpretation skills, prompts and leading questions may be needed to bring out the following points:

Figure 1.



- Current velocity changes constantly, but in an overall pattern that repeats about every 12 hours. This corresponds to the typical 12-hour tidal cycle.
- When the direction of the current changes (for example, around 22:00 on 15/07 when the current velocity is zero), fluorescence and water temperature (middle and bottom graphs) increase sharply, and this pattern is repeated in each of the five cycles shown.

- The upper graph shows an increase in optical backscatter (turbidity) approximately one hour after maximum current speeds in either direction (for example, around 20:00 on 15/07 and around 02:00 on 16/07).
- In addition to these overall patterns of variation, all of these parameters vary from one measurement to the next, giving the graphs a fuzzy appearance. This is an excellent illustration of why one measurement is rarely enough to understand the physical conditions in a marine environment, and why devices such as benthic landers are needed to understand the range of conditions that exist in submarine canyons.

The BRIDGE Connection

www.vims.edu/bridge/ – Scroll over “Ocean Science Topics” in the navigation menu to the left, then “Habitats,” then “Coastal,” then “Coral” for resources on corals and coral reefs. Click on “Physics” for resources on ocean currents.

The “Me” Connection

Have students write a short essay about how discoveries in deepwater canyons might one day affect their own lives.

Connections to Other Subjects

English Language Arts, Mathematics, Earth Science

Assessment

Student reports and class discussions provide opportunities for assessment.

Extensions

Have students visit <http://oceanexplorer.noaa.gov/explorations/13midatlantic/welcome.html> to find out more about the Deepwater Canyons 2013 - Pathways to the Abyss Expedition.

Multimedia Discovery Missions

<http://oceanexplorer.noaa.gov/edu/learning/welcome.html> Click on the links to Lessons 3, 5, 6, and 8 for interactive multimedia presentations and Learning Activities on Deep-Sea Corals, Chemosynthesis and Hydrothermal Vent Life, Deep-Sea Benthos, and Ocean Currents.

Other Relevant Lesson Plans from NOAA's Ocean Exploration Program

Please see the *Design a Benthic Lander!* lesson [http://oceanexplorer.noaa.gov/explorations/12midatlantic/background/edu/media/dwc12_lander56.pdf].

Other Resources

Roberts, J. M., A. J. Davies, L. A. Henry, L. A. Dodds, G. C. A. Duineveld, M. S. S. Lavaleye, C. Maier, R. W. M. van Soest, M. J. N. Bergman, V. Hühnerbach, V. A. I. Huvenne, D. J. Sinclair, T. Watmough, D. Long, S. L. Green, and H. van Haren. 2009. Mingulay reef complex: an interdisciplinary study of cold-water coral habitat, hydrography and biodiversity. *Mar. Ecol. Prog. Ser.* 397: 139–151.

Please see the *Design a Benthic Lander* lesson referenced above for more resources.

Correlations to Next Generation Science Standards (NGSS)

The objectives of this lesson address the following Performance Expectations:

Objective: Students will construct and defend inferences about types of organisms that may colonize settlement plates attached to benthic landers deployed in mid-Atlantic deepwater canyons.

MS-LS2-1. Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.

[Clarification Statement: Emphasis is on cause and effect relationships between resources and growth of individual organisms and the numbers of organisms in ecosystems during periods of abundant and scarce resources.]

Objective: Students will interpret data from benthic lander sensors to identify patterns and variability of selected physical conditions in a deepwater marine ecosystem.

MS-LS2-4. Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations

[Clarification Statement: Emphasis is on recognizing patterns in data and making warranted inferences about changes in populations, and on evaluating empirical evidence supporting arguments about changes to ecosystems.]

Correlations to Common Core State Standards for English Language Arts

RI.4 – Determine the meaning of words and phrases as they are used in a text, including figurative, connotative, and technical meanings

SL.1 – Engage effectively in a range of collaborative discussions

(one-on-one, in groups, and teacher-led) with diverse partners on grade 9–12 topics, texts, and issues, building on others’ ideas and expressing their own clearly.

L.4 – Determine or clarify the meaning of unknown and multiple-meaning words and phrases, choosing flexibly from a range of strategies.

L.6 – Acquire and use accurately general academic and domain-specific words and phrases, sufficient for reading, writing, speaking, and listening at the college and career readiness level; demonstrate independence in gathering vocabulary knowledge when considering a word or phrase important to comprehension or expression.

Correlations to Common Core State Standards for Mathematics

5.G.2. Represent real world and mathematical problems by graphing points in the first quadrant of the coordinate plane, and interpret coordinate values of points in the context of the situation.

Ocean Literacy Essential Principles and Fundamental Concepts

Essential Principle 1.

The Earth has one big ocean with many features.

Fundamental Concept b. An ocean basin's size, shape and features (such as islands, trenches, mid-ocean ridges, rift valleys) vary due to the movement of Earth's lithospheric plates. Earth's highest peaks, deepest valleys and flattest vast plains are all in the ocean.

Essential Principle 5.

The ocean supports a great diversity of life and ecosystems.

Fundamental Concept e. The ocean is three-dimensional, offering vast living space and diverse habitats from the surface through the water column to the seafloor. Most of the living space on Earth is in the ocean.

Fundamental Concept f. Ocean habitats are defined by environmental factors. Due to interactions of abiotic factors such as salinity, temperature, oxygen, pH, light, nutrients, pressure, substrate and circulation, ocean life is not evenly distributed temporally or spatially, i.e., it is "patchy". Some regions of the ocean support more diverse and abundant life than anywhere on Earth, while much of the ocean is considered a desert.

Fundamental Concept g. There are deep ocean ecosystems that are independent of energy from sunlight and photosynthetic organisms. Hydrothermal vents, submarine hot springs, and methane cold seeps rely only on chemical energy and chemosynthetic organisms to support life.

Essential Principle 6.**The ocean and humans are inextricably interconnected.**

Fundamental Concept f. Coastal regions are susceptible to natural hazards (such as tsunamis, hurricanes, cyclones, sea level change, and storm surges).

Essential Principle 7.**The ocean is largely unexplored.**

Fundamental Concept a. The ocean is the last and largest unexplored place on Earth—less than 5% of it has been explored. This is the great frontier for the next generation’s explorers and researchers, where they will find great opportunities for inquiry and investigation.

Fundamental Concept b. Understanding the ocean is more than a matter of curiosity. Exploration, inquiry and study are required to better understand ocean systems and processes.

Fundamental Concept d. New technologies, sensors and tools are expanding our ability to explore the ocean. Ocean scientists are relying more and more on satellites, drifters, buoys, subsea observatories and unmanned submersibles.

Send Us Your Feedback

In addition to consultation with expedition scientists, the development of lesson plans and other education products is guided by comments and suggestions from educators and others who use these materials. Please send questions and comments about these materials to:

oceanexeducation@noaa.gov.

For More Information

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Credit

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Guidance for Mission Log Review

Microbial Architects

(August 16, 2012) by Christina Kellogg [<http://oceanexplorer.noaa.gov/explorations/12midatlantic/logs/aug16/aug16.html>]

1. Why do you think Dr. Kellogg chose *Microbial Architects* as the title for this Mission Log?
2. Why are different kinds of materials used for settlement plates attached to benthic landers?
3. Dr. Kellogg describes an investigation of microbial biofilms using settling plates attached to a benthic lander. How would you modify the procedure she describes if you wanted to find out which microbes are the first ones to appear on the settling plates?

Microbial Ecology of Deepwater Canyons

(U.S. Geological Survey Fact Sheet 2011–3102, August 2011)[<http://pubs.usgs.gov/fs/2011/3102/pdf/2011-3102.pdf>]

4. What are two ways that microorganisms may help corals?
5. How may microorganisms benefit animals that live in soft sediments?

Benthic Landers: Critical Tools For Use in Deep-sea Research

by Steve W. Ross [<http://oceanexplorer.noaa.gov/explorations/12midatlantic/background/benthiclanders/benthiclanders.html>]

6. Dr. Ross says, “Detailed, longer-term data of physical variability are key to understanding unique slope habitats, such as deep-sea coral reefs, and canyons.” What does “physical variability” mean, and why do you think Dr. Ross says detailed, longer-term data about physical variability are key to understanding slope habitats?
7. What do “temporally” and “spatially” mean?
8. How many times will each benthic lander measure temperature in one day?

Energy Flow through Submarine Canyons

(August 20, 2012) by Dr. Gerard Duineveld [<http://oceanexplorer.noaa.gov/explorations/12midatlantic/logs/aug20/aug20.html>]

9. Why does Dr. Duineveld say that we need continuous observations over a long time period to understand how particles flow in submarine canyons?
10. How could the presence or absence of fresh algal particles help explain where animal communities live in submarine canyons?

Figure 1.

